Limitations of a Joint Model for Multibody Systems

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In this study, model distortions, due to applying a joint model for interconnecting deformable and undeformable bodies, are highlighted. Specifically, the overall dynamics are restricted, by that the joint model prohibits any rotational component of the displacements along the interface between joint and deformable body. A stress analysis for a loaded semi-trailer hinged to a truck is a typical example where the joint model could distort the analysis.

In the design of most mechanical systems, it is key to understand the dynamics and the durability of the system. Even for many complex systems, there are both efficient and accurate ways to numerically model the dynamics. Naturally, performing numerical simulations are significantly cheaper and less time-consuming than conducting prototype testing. Hence, numerical simulations has become an increasingly vital part in the development of many mechanical systems over the past decades.

For a car, a useful model simplification is to view the car as a set of body parts interconnected by springs, dampers and actuators; a so-called multibody system. In the crudest simplification, all compressions are assumed to occur over the interconnecting elements. Then, the body parts can be modeled as undeformable. The dynamics of an undeformable body can be fully described as a point mass motion at its center of mass.

Consider a loaded semi-trailer connected to a truck through an undeformable joint. If the interest is to estimate the weight the semi-trailer can withstand, it should be modeled as a deformable body. To describe the displacements of a deformable body numerically, the body is covered by finite many points, and the dynamics is solved locally through influences between adjacent points. If the joint is connected to the truck above its back-wheels, the truck can still be modeled as an undeformable multibody system.

Retrieving a satisfactory and well-defined joint model, for interconnecting deformable and undeformable bodies, is still an open topic. The challenging aspect is to describe the interface, between joint and deformable body, in a well-defined way, with respect to both the undeformable joint and the deformable body.

In contrast to a more common joint model, the examined model is well-defined. To apply a satisfactory well-defined model is strongly favorable, since it increases the reliability of retrieved results. However, the examined model prohibits any rotational component of the displacements along the interface between joint and deformable body. The restricted motion slightly distorts the deformation of the semi-trailer, and thereby overestimate the corresponding stresses. In the study, the model distortion is clearly illustrated for a basic two-body system, where an undeformed body is hinged to a deformable one.

Due to the model restrictions, the examined model is expected to give less reliable results than the more common one. However, due to limitations of both models, further investigations are encouraged. To retrieve novel satisfactory joint models are important in order to retrieve more reliable results for mechanical systems, such as the above-mentioned semi-trailer truck, as well as for slider-crank mechanisms in an engine and the rotor blade configurations on a helicopter.